Padmavathi Iyengar has earned a M.Sc. in civil and environmental engineering and is now studying for her M.Sc. in geology at the University of Missouri in Kansas City. Her advisor is Dr. Jejung Lee and her research topic is Seismic Properties of Coal During Sorption of CO_2 and CH_4.

EXECUTIVE SUMMARY

A major part of research is being conducted in the field of Carbon Sequestration in many parts of the world. Only in the past 10 to 15 years carbon sequestration practices has been accepted through field demonstrations as quoted by Dan Nye, Tim Walainis, and Tara Whipkey from the University of Michigan (Tara Whipkey *et al.*, 2007). According to U.S. EPA, major sources for carbon dioxide emissions are fossil fuel combustion followed by, iron and steel manufacturing and cement manufacturing industries (U.S. EPA, 2011). There are many ways to reduce the amount of emitted carbon dioxide gas from the atmosphere. Carbon sequestration in coal bed aquifers is one among them. This green house gas is injected into coal seams in exchange for methane; a type of natural gas. Different types of coals react differently under different field conditions. The adsorption capacity of coal depends on pressure, temperature, and coal characteristics such as composition, rank, ash content and moisture content of coal (Toribio *et al.*, 2006).

Seismic methods are used to study the subsurface and elastic properties of soil and rock for various purposes. They are one of the most effective measurements of the subsurface environment, used both in the field and laboratory scale experiments. They are also cost effective and nondestructive (Lee *et al.*, 2007). In the present study a relationship between seismic measurements and the behavior of coal seams during sorption of carbon dioxide and methane is aimed to be achieved. Coal is highly attenuative and will be thoroughly characterized in this project, by testing with different sample sizes. In-situ conditions of pressure and temperature will

be maintained in this laboratory scale experiment, with the help of pressure gauges and temperature monitoring devices. This study will measure specific seismic characteristics such as compressional velocity, reflectivity, attenuation coefficient, anisotropy and travel time delay of signal due to volumetric deformation and change of gas composition in coal specimen. Prior to the seismic studies the coal samples will be tested for shrinkage and swelling mechanism due to the sorption of carbon dioxide and methane on coal. The study is also aiming to study the microscopic images of cleat structure in coal samples for image analyze, before and after sorption.

BACKGROUND

Coal is a type of sedimentary rock and unlike other types of rocks; it is made up of macerals. Dead plants buried in fresh or brackish water over a long period of time under anaerobic conditions results in coal (Boggs, 2001). Coal is made up of matrix and cleat systems and has high affinity to carbon molecules (Harpalani and Schraufnagel, 1989). Unmineable coal beds are not only used for carbon sequestration but also used for enhanced coal bed methane (ECBM) recovery (Robertson, 2010). Coal beds under hydrostatic pressure are dewatered to decrease the pressure and recover natural gas (methane) that is freely available in the pore spaces of coal matrix. By injecting carbon dioxide gas into coal seams, the adsorbed methane is desorbed and results in an enhanced production of methane gas. As reported by Levine in 1996 and quoted by L. J. Pekot and S. R. Reeves, a greater degree of swelling results due to carbon dioxide adsorption than methane desorption. This gas exchange process induces strain and results in swelling and shrinkage of coal.

GOALS AND OBJECTIVES

The hypothesis of the proposed research is that strain induced due to sorption of CO_2 and CH_4 onto coal will alter seismic or elastic properties of coal as seismic wave velocity and attenuation are affected by gas saturation, permeability, and porosity of coal. Shrinkage and swelling rates will also be analyzed along with elastic properties. The main objective of the present research is to investigate the effect of CO_2/CH_4 sorption on volumetric deformation of coal using a seismic method on a laboratory scale. The specific objectives are:

1) Acquire the rates of shrinkage and swelling of coal matrix due to CO_2 and CH_4 injection under in-situ conditions.

2) Determine seismic characteristics including compressional velocity; reflectivity; attenuation coefficient; anisotropy; and travel time delay of signal due to volumetric deformation and change of gas composition in coal specimen.

3) Investigate the feasibility of field scale application by changing the frequency of seismic source and pressure surrounding coal specimen.

4) Quantifying carbon dioxide adsorption capacity of coal in a laboratory scale.

5) To investigate cleat structures before and after sorption practices with high magnification Scanning Electron Microscope or X-ray computerized Tomography.

CLIENTELE

The results of the proposed work will be beneficial to geo-environmental problems, such as enhanced methane extraction in deep coalbed aquifers and also provide better understanding of sequestration of carbon dioxide. As many industries might be affected by the CO_2 taxation soon to be implemented by the government, along with many other publications the results of this seismic analyses could increase the potential for economic feasibility of CO_2 and CH_4 sorption technique.

METHODS

Adsorption and Desorption

The coal sample will be subjected to gas pressures in an air sealed steel chamber. Pressure gauges and external N_2, CO2 and CH_4 gas cylinders are connected through multiple unidirectional steel valve systems. The pressure inside the chamber and time can be logged into a computer, connected to the sorption setup.

Strain Gauges

Strain Gauges with resistance of 120 Ω and 350 Ω connected as a full bridge will be glued to the exposed surface of the coal samples and the deformation of the surface will be recorded by a data logger CR-10X.

Pressure Transducers

To record the seismic properties of the coal sample in the reactor chamber pressure transducers of various frequencies such as 1.0 MHz, 7.5 MHz and 15 MHz will be attached to a steel bracket that would be installed inside the chamber. The input and output signals will be monitored through a pulser/ receiver.

Data Analyses

Final stage is data analyses, where I could analyze the dependency of various parameters on coal sorption process.

AVAILABLE RESOURCES

- The KU has agreed to the request of using their sorption apparatus that belongs to the Petroleum Engineering Department.
- Dr. Jejung Lee from the UMKC has 2 sets of 5 pieces each strain gauge have been allowed for the project. Dr. Anil Misra and Dr. Jejung Lee have also agreed to lend pressure transducers and pulser/receiver setup for the transducers to capture the elastic properties of coal.
- Dr. Dave Newell from KGS has been kind enough to supply different Coal samples for the experiment from the immense core collection owned by KGS

NEEDED RESOURCES

EQUIPMENT/ SUPPLIES/ COMMUNICATION

- The sorption apparatus will be requested for the project from the University of Kansas, Lawrence as it will not be allowed outside their campus.
- Travelling to campus from UMKC for the experiment is also required in order to conduct the experiment.
- The existing sorption apparatus is not designed for pressure transducers installation and for passing strain gauge wires through the air sealed lid of the pressurized steel chamber and hence has to be manufactured.
- Scanning Electron Microscope or X-ray computerized Tomography is needed to accomplish specific objective # 5.

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